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IMPACT OF ISOLATED AND COMBINED RESISTANCE TRAINING AND PLYOMETRIC TRAINING ON STRENGTH AND POWER OUTPUTS

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ABSTRACT
Shafeeq, V. A.; Dhinu, M. R.; Jackson, P.; Shine Singh, J. P. Impact of isolated and combined resistance training and plyometric training on strength and power outputs. Brazilian Journal of Biomotricity. v. 7, n. 2, p. 117-127, 2013. The present investigation intended to determine the impact of resistance training, plyometric training and combined resistance and plyometric training on strength and power outputs in young boys. Sixty physically active students, aged between 17-20 years (mean age +/-1.9 years) participated in the study and they were randomly assigned into four equal groups with fifteen subjects each. Group I was involved with resistance training, group II plyometric training, group III combined resistance and plyometric training and group IV acted as control group. The experimental groups underwent their respective experimental treatment for eight weeks, 3 days a week and one session per day. Control group was not exposed to any specific training apart from their regular activities. Leg strength, elastic strength and explosive power were taken as variables for this investigation. The pre and post tests were conducted one day before and after the experimental treatment. The collected data were treated with Analysis of Covariance and Scheffe’s test was applied as a post hoc test to determine which of the paired means differed significantly. The result of the study revealed that all the three trainings such as resistance training, plyometric training and combined resistance and plyometric training produced significant improvement on leg strength, elastic strength and explosive power (p < 0.05) as compared to control group. It was concluded that the combinatory training protocol produced greater impact than resistance and plyometric training given alone.

Key-Words: Elastic strength, explosive power, leg strength, plyometric training, Resistance training.
INTRODUCTION

In many sports success depends heavily upon the athlete's explosive leg power and muscular strength. In jumping, throwing, track and field events and other activities, the athlete must be able to use strength as quickly and forcefully as possible. Marked evidence indicates that regular participation in a resistance training program or a plyometric training program can improve measures of strength and power in adults (CHU, 1998; FLECK and KRAEMER, 1997).

Resistance training is defined as a specialized method of conditioning that involves the progressive use of a wide range of resistive loads and a variety of training modalities (eg. free weights, weight machines, elastic cords and body weight) designed to enhance fitness and sports performance and it is an anaerobic form of exercises (TANG et al., 2008). Resistance training enhances the ability of the body to perform at very high force or power outputs for a very short period of time (BAECHLE THOMAS, 1994). Enhancement of the attributes associated with physical performance like endurance, strength, power and speed is possible with appropriate resistance training methods (STONE 1990).

Plyometric training has been established as a training method that improves the muscle-tendon unit’s ability to tolerate stretch loads and the efficiency of the stretch-shorten cycle (SSC). This training involves and uses, practicing plyometric movements to toughen tissues and train nerve cells to stimulate a specific pattern of muscle contraction, so the muscles generates as strong a contraction as possible in the shortest amount of time (CHU, 1998).

High level elastic strength requires good coordination and a combination of high speed and strength of muscle action (ASMUSSEN and BONDE-PETERSON, 1974). Plyometric exercises with weights are the best method to improve elastic power (BLAKEY and SOUTHARD, 1987). Explosive power is the ability of the neuromuscular system to overcome resistance with a high speed of contraction. Plyometric training helps to develop the contractile protein that gives the muscle in pulling power (EDWIN and GORDON, 2007). A number of studies have demonstrated positive results of plyometric training compared to non-exercising control groups. Luebbers et al. (2003) examined the effect of a plyometric training program on vertical jump performance and anaerobic power. The Margaria Staircase power test and vertical jump test were used, and the results showed anaerobic power increased in both groups. Other studies have revealed that low impact plyometric exercise is not only safe but an effective means of increasing low body power in the form of vertical jump performance (VILLARREAL et al., 2010; RUBLEY et al., 2011).

Resistance training is found to be valuable for developing explosive power (BLAKEY and SOUTHARD, 1987; BAKER, 2003) and more ideal to improve jumping ability (MCNEAL and SANDS, 1998; CHRISTOU, 2006). Arabatzi et al. (2010) conducted a study with a control group and three training groups consisting of an Olympic lifting group, a plyometric group, and a combination Olympic lifting and plyometric group. They trained three days per week for eight weeks and the results showed vertical jump improvements in all three training groups. The comparison of plyometric exercises and weight-training protocols has produced controversial results. Plyometric protocols have been shown to be more effective (VERKHOSHANSKI and TATYAN, 2003), equally effective (ANDERST et al., 1994; FATOUROS, 2000) or less effective (STONE, 1990; VERKHOSHANSKI and TATYAN; 2003) than weight training in improving the vertical jumping ability. The combination of plyometric exercises and weight training increased (BEHM and SALE, 1993; FATOUROS, 2000) or maintained (STONE, 1990) vertical jumping performance.

It is intriguing as to whether plyometric training and resistance training can provide combinatory effects in younger populations. Given the growing popularity of youth strength and conditioning programs, it is important to ascertain the most effective method for enhancing fitness performance in adolescents. Therefore, the purpose of the present investigation was to analyse the impact of resistance training, plyometric training and combined resistance and plyometric training on strength and power outputs in University students.
MATERIAIS E MÉTODOS

Participants

Sixty physically active male students of Calicut University, India, were randomly selected as participants. Their mean age was 19.5 (±2.6) years, mean height 169 (±4.9) cm and weight 65 (±5.6) kg. They were randomly assigned into four equal groups with fifteen participants each. All of the participants were active in physical activities and sports but none were being trained by means of a resistance and plyometric training program. All of the participants had successfully passed a physical examination and completed a medical history questionnaire in which they were screened for any possible injury or illness. Participants were excluded if they had a chronic disease or had an orthopedic condition that would limit their ability to perform exercise. The participants received all the necessary information about the study’s procedures. Written consent was obtained from each of the participants for taking part in the investigation.

Testing procedures

Leg strength, elastic strength and explosive power were taken as variables for this investigation. The leg strength was measured by using leg dynamometer, elastic strength was measured by using five bunny hopes and explosive power was assessed by standing broad jump test.

Group I was involved with resistance training (RT), group II was given plyometric training (PT), group III underwent resistance training and plyometric training for alternate days (RPT) and group IV acted as control (CG). The exercise groups trained thrice per week on nonconsecutive days (Monday, Wednesday and Friday) for eight weeks with one session on each day under carefully monitored and controlled conditions. Control group was not exposed to any specific training apart from their regular activities.

Training protocol

Prior to each training session, all subjects participated in a ten minute warm-up period which included jogging at a self selected comfortable pace followed by calisthenics. Before the commencement of the experimentation, the investigator recorded 1RM for all the two groups taking each subject separately.

Progressive method was followed while performing resistance exercises which included squat, bench press, push press, overhead press, standing calf raise, biceps curl, front squat, incline press, upright row, standing calf raise and triceps extension. The intensity ranged from 60% to 90% of 1RM. The progressive plyometric training program used in this study was based on findings from previous investigations as well as observations from conditioning coaches and sports medicine professionals (CHU et al, 2006; HEWETT et al., 1999). The components of this program included preparatory movement training and plyometric training. The plyometric exercises followed were box jump (depth or drop jump), tuck jump, split jump, bounding, steps, single leg hop (alternate leg), hurdle jump and medicine ball exercise. These exercises were performed for ninety minutes per day. Group III performed combined resistance and plyometric training on alternate days. Participants were taught how to record their data on workout logs and did so throughout the training period. The instructors reviewed the workout logs daily and made appropriate adjustments in training weight and repetitions throughout the study period. The pre and post test data were collected one day before and after the experimental treatment. The details of training programmes are shown in Table 1 and Table 2.
Table 2 - Plyometric Training (PT) programme

<table>
<thead>
<tr>
<th>Group</th>
<th>Component</th>
<th>Week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Plyometric</td>
<td>Intensity</td>
<td>60</td>
</tr>
<tr>
<td>Training</td>
<td>Repetitions</td>
<td>10 - 12</td>
</tr>
<tr>
<td>Sets</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Statistical Analysis

Mean and standard deviation were calculated for leg strength, elastic strength and explosive power of all four groups an. The data were analyzed by using analysis of covariance (ANCOVA). When the ‘F’ value was found to be significant for adjusted post-test mean, Scheffe’s test was used as post hoc test to determine the significant difference between the paired mean. All analysis was carried out using SPSS version and statistical significance was set at p < 0.05.

RESULTS

The mean and standard deviation scores of leg strength are presented in Table 3. (ANCOVA) procedures demonstrated a significant difference (P < 0.05) between experimental groups and the control group. The Scheffe’s post hoc analysis revealed that significant difference in leg strength exist between all the experimental groups and control group and also between RT and PRT group. But no differences were observed between RT and PT groups or RT and RPT group. The pre and post test mean values of experimental groups and control group on leg strength were graphically represented in the figure 1.

Table 3 - Mean ± SDs of pre and post test scores of leg strength of all four groups

<table>
<thead>
<tr>
<th></th>
<th>Resistance Training (RT)</th>
<th>Plyometric Training (PT)</th>
<th>Combined Res &amp; Ply (RPT)</th>
<th>Control Group (CG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test Mean</td>
<td>73.87 (±5.68)</td>
<td>74.13 (±5.21)</td>
<td>73.60 (±6.06)</td>
<td>73.20 (±6.54)</td>
</tr>
<tr>
<td>Post-test Mean</td>
<td>82.27 (±4.71)*</td>
<td>80.40 (±4.08)*†</td>
<td>85.60 (±4.15)*†</td>
<td>74.40 (±5.96)</td>
</tr>
<tr>
<td>Change percent</td>
<td>11.4 %</td>
<td>8.46 %</td>
<td>16.3 %</td>
<td>1.64 %</td>
</tr>
</tbody>
</table>

* Significant difference compared with the control group (P< 0.05).
† Significant difference between the PT and RPT groups (P< 0.05)
Table 4 represent the mean and standard deviation scores of elastic strength of all the groups. Compared to the control group, all the three experimental groups (RT, PT & RPT) exhibited significantly higher values of elastic strength (P < 0.05). There was no significant difference between any of the experimental groups. The results were graphically presented in the figure 2.

**Table 4- Mean ± SDs of pre and post test scores of elastic strength of all four groups.**

<table>
<thead>
<tr>
<th></th>
<th>Resistance Training (RT)</th>
<th>Plyometric Training (PT)</th>
<th>Combined Res &amp; Ply (RPT)</th>
<th>Control Group (CG)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-test</strong></td>
<td>9.49 (±0.38)</td>
<td>9.39 (±0.43)</td>
<td>9.56 (±0.43)</td>
<td>9.38 (±0.43)</td>
</tr>
<tr>
<td><strong>Post-test</strong></td>
<td>10.50 (±0.33) *</td>
<td>10.41 (±0.30) *</td>
<td>10.71 (±0.34) *</td>
<td>9.44 (±0.34)</td>
</tr>
<tr>
<td><strong>Change percent</strong></td>
<td>10.6 %</td>
<td>10.9 %</td>
<td>12.0 %</td>
<td>0.64 %</td>
</tr>
</tbody>
</table>

* Significant difference compared with the control group (P< 0.05).
Table 5 represents the mean and standard deviation scores of explosive power of the participants in various groups. It indicated significant difference existed between the experimental groups and control group (P < 0.05). There was no significant difference between any of the experimental groups. The pre and post test mean values of experimental groups and control group on elastic strength were graphically represented in the figure 3.

Table 5 - Mean ± SDs of pre and post test scores of explosive power of all four groups

<table>
<thead>
<tr>
<th>Test</th>
<th>Resistance Training (RT)</th>
<th>Plyometric Training (PT)</th>
<th>Combined Res &amp; Ply (RPT)</th>
<th>Control Group (CG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test Mean (±S.D)</td>
<td>2.12 (±0.15)</td>
<td>2.10 (±0.12)</td>
<td>2.13 (±0.12)</td>
<td>2.08 (±0.13)</td>
</tr>
<tr>
<td>Post-test Mean (±S.D)</td>
<td>2.34 (±0.15)*</td>
<td>2.37 (±0.11)*</td>
<td>2.43 (±0.10)*</td>
<td>2.11 (±0.10)</td>
</tr>
<tr>
<td>Change percent</td>
<td>10.4 %</td>
<td>12.9 %</td>
<td>14.1 %</td>
<td>1.44 %</td>
</tr>
</tbody>
</table>

* Significant difference compared with the control group (P< 0.05).
DISCUSSÃO

The results of the present study showed that resistance training and plyometric training for a period of eight weeks have a significant effect in increasing leg strength, elastic strength and explosive power but the combined resistance and plyometric training programme was found to be more effective than resistance training and plyometric training alone. This improvement could be due to neuromuscular adaptations, such as increased inhibition of antagonist muscles as well as a better activation and contraction of synergistic muscles or increase in muscle fiber size (GOLLNICK, 1981; POTTEIGER, 1999).

Many research studies suggest that resistance training may be valuable for the improvement of leg strength (LOSNEGARD et al., 2011; GOROSTIAGA et al., 2006; HUNDER et al., 2001; ROBERT et al., 2002). The results of the present study support this fact. The various training components like sets, repetitions, rest and intervals could be manipulated the training loads used from the most important factor that determine the training stimuli and the consequent training adaptations (MYER et al., 2006; JONES et al., 2001).

Plyometric training is very valuable for determining the variables such as elastic strength and explosive power (CAMPO et al., 2009). These results concur with previous studies (utilising training duration between 4 to 24 weeks and various session frequencies), which found plyometric training with the support of weights to improve elastic and explosive power performance (FORD et al., 1983; GOMEZ PEREZ et al., 2008). Roger et al. (2007) and Anderst et al. (1994) reported an increase in elastic and explosive power performance after 12 weeks plyometric training. This is conversant with the results of the present study and also with the findings of Faigenbaum et al. (2007). The findings of the present study provide further support to the notion that plyometric training can demonstrate benefits in a short period of time, indicating that twenty four sessions of plyometric training suffice for initial improvements. Withers (1970) found that progressive weight training results an increase in power. Thorstensson (1976) has observed that strength training improves the performance of standing broad jump.

Markovic (2007) looked at the effect of plyometric training on the performance of four types of vertical jump testing such as squat jump, countermovement jump, countermovement jump with arm
swing, and drop jump tests. The results indicated increases in the height of all types of the vertical jump tests. The increases ranged from 4.7% in the squat and drop jump, to 7.5% in the countermovement jump with arm, and 8.5% in the countermovement jump. During a plyometric movement, the muscles undergo a very rapid switch from the eccentric phase to the concentric phase. This stretch-shortening cycle decreases the time of the amortization phase that in turn allows for greater than normal power production. The muscles store elastic energy and stretch reflex responses are essentially exploited in this manner, permitting more work to be done by the muscle during the concentric phase of movement (RAHIMI and BEHPUR, 2005).

Myer et al. (2005) observed that a six week, multi-component training program which included resistance training and plyometric training significantly enhanced strength, jumping ability in female adolescent athletes as compared to a non-exercising control group.

Results from many investigations support the findings of the present study that combining plyometric training with resistance training has greater effects in enhancing muscular and motor performance. For example, Fatouros et al. (2000) reported that after 12 weeks of training adult subjects who combined plyometric training with resistance training increased vertical jump performance by 15% whereas gains of 11% and 9% were reported for subjects who performed only resistance training or plyometric training, respectively.

Adams (1992) investigated with three training groups consisting of a squat group, a plyometric group, and a combination squat and plyometric group looking at increases in power production through the use of a vertical jump test. The results indicated that a combination of squats and plyometric training program is more effective than either training protocol alone at increasing power production. Similarly Rahman Rahimi (2005) has pointed out that short term plyometric training is capable of improving the vertical jumping ability, muscular strength and anaerobic power but its combination with weight training is even more beneficial. Thus the effects of plyometric training and resistance training may actually be synergistic, with their combined effects being greater than each program performed alone.

PRACTICAL APPLICATIONS

- Generally, leg strength and strength out puts in athletes are improved by either resistance or plyometric training alone, however, coaches and trainers shall take into consideration that a combinatory effect of these two training methods can be utilized to create a greater impact.
- Similarly, youth conditioning programmes incorporating different types of training and different velocities may be more effective for enhancing strength and power performance
- In the present study progressive overload principle was followed in which intensity and training volume was gradually increased which helped the subjects to adjust effectively. Especially in plyometric training protocol, progressive principle may result in better outcomes.

CONCLUSION

It was demonstrated that the addition of plyometric training to a resistance training program was more effective than resistance or plyometric training alone in improving strength outputs in young boys. The findings highlight the potential value of combined fitness training in a conditioning program aimed at maximizing power performance in youth, at least in the short-term. Up to ten weeks into a training program, the majority of strength and power gains can be accounted for by neurological adaptations. Hence, a study for a longer period of training, possibly sixteen weeks in length, may be valuable. Moreover, study with the added variable of thigh girth measurements could investigate increases in strength due to muscular hypertrophy. Also, it is probable that higher intensity plyometric and resistance exercises would produce different results.
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REFERÊNCIAS


